Unequal Arrow Based Printed Antenna for Marine Communications

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***Abstract*— This paper represents an unequal arrow based printed antenna for many kind of wireless communication applications. Unequal arrow based can be achieved with asymmetries. The emphasis is on to increase the bandwidth of the antenna. In recent years, great interest was focused on Printed antennas for their small volumes, low profiles, excellent integration, low costs and good performance. With the continuous growth of wireless communication service and the constant miniaturization of communication equipment, there are higher and higher demands for the volume of antennas, integration and working band. Resonant frequency has been reduced drastically consists of two triangular and one unequal shaped slot located from the conventional microstrip patch antenna. It is shown that the simulated results are in acceptable agreement. More importantly, it is also shown that the differentially-driven microstrip antenna has higher gain of simulated 3.73 dBi at 9.40635GHz and 0.33 dBi at 13.3046GHz and beam width of simulated 136.1890 at 9.40635GHz & 131.270at 13.3046GHz of the printed antenna. Compared to a conventional microstrip patch antenna, simulated antenna size has been reduced by 53.26% with an increased frequency ratio. The initial design and optimization of the printed antenna is operating in Ku band (12-18GHz).Zeland IE3D [18] software has been performed.**

Keywords- Compact, Patch, Slot, Resonant frequency, Bandwidth, Printed Antenna.

I. INTRODUCTION

A microstrip patch antenna has the advantages of low cost, light weight, and low profile planner configuration. In recent years, demand for small antennas on wireless communication has increased the interest of research work on compact microstrip antenna design among microwave and wireless engineers [1-6]. Because of their simplicity and compatibility with printed-circuit technology microstrip antennas are widely used in the microwave frequency spectrum. Simply a microstrip antenna is a rectangular or other shape, patch of metal on top of a grounded dielectric substrate. Microstrip patch antennas are attractive in antenna applications for many reasons. They are easy and cheap to manufacture, lightweight, and planar to list just a few advantages. Also they can be manufactured either as a stand-alone element or as part of an array. However, these advantages are offset by low efficiency and limited bandwidth. In recent years much research and testing has been done to increase both the bandwidth and radiation efficiency of microstrip antennas [7-8].Bandwidth improves as the substrate thickness is increased, or the dielectric constant is reduced, but these trends are limited by an inductive impedance offset that increases with thickness.

Due to the recent interest in unequal arrow based printed antenna was developed to meet the need for a cheap, low profile, broadband antenna. This antenna could be used in a wide range of applications such as in the marine communications. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with $\varepsilon_r = 4.4$) has a gain of 4.18 dBi and presents a size reduction of 53.26% when compared to a conventional microstrip patch (10mm X 6mm). The simulation has been carried out by IE3D [18] software which uses the MoM method. Due to the small size, low cost and low weight this antenna is a good entrant for the application of C-Band of satellite communication and X-Band for microwave communication. Now this global Ku- band markets have become very expensive, and there is now we started look at X-band.

The X-band and Ku-Band defined by an IEEE standard for radar applications and satellite engineering with frequencies that ranges from 8.0 to 12.0GHz and 12.0 to 18.0GHz[10] respectively. The X [11-13] band is used for short range tracking, missile guidance, marine, radar and air bone intercept. Especially it is used for radar communication ranges roughly from 8.29GHz to 11.4GHz .In this paper the microstrip patch antenna is designed for use in marine communication at 13.3046GHz The results obtained provide a workable antenna design for incorporation in a marine communications. In the maritime community, satellite communication [14-17] systems such as Inmarsat provide good communication links to ships at sea. These links use a VSAT type device to connect to geosynchronous satellites, which in turn link the ship to a land based point of presence to the respective nation's telecommunications system.

II. ANTENNA DESIGN

The configuration of the conventional printed antenna is shown in Figure 1 with L=6 mm, W=10 mm, substrate (PTFE) thickness h = 1.6 mm, dielectric constant $\varepsilon_r = 4.4$. Coaxial probe-feed (radius=0.5mm) is located at W/2 and L/3. Assuming practical patch width W= 10 mm for efficient radiation and using the equation [6],

$$f_r = \frac{c}{2W} \times \sqrt{\frac{2}{(1+\varepsilon_r)}}$$

Where, c = velocity of light in free space. Using the following equation [9] we determined the practical length L (=6mm).

$$L = L_{eff} - 2\Delta L$$

Where, $\frac{\Delta L}{h} = \left[0.412 \times \frac{(\varepsilon_{reff}+0.3)\times(W/h+0.264)}{(\varepsilon_{reff}-0.258)\times(W/h+0.8)}\right]$

$$\varepsilon_{reff} = \left[\left(\frac{\varepsilon_r+1}{2}\right) + \frac{\varepsilon_r-1}{\left(2\times\sqrt{\left(1+12\times\frac{h}{W}\right)}\right)}\right]$$

and $L_{eff} = \left[\frac{c}{2 \times f_r \times \sqrt{\epsilon_{eff}}}\right]$

Where, L_{eff} = Effective length of the patch, $\Delta L/h$ =Normalized extension of the patch length, ε_{reff} = Effective dielectric constant [9].

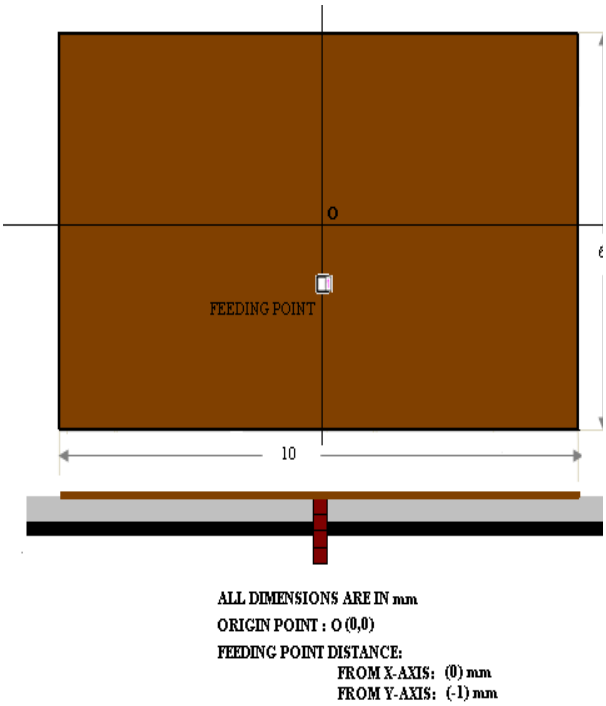

Figure 1. Conventional Antenna configuration

Figure 2 shows the configuration of simulated printed antenna designed with similar PTFE substrate. The upper right point triangular shaped the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

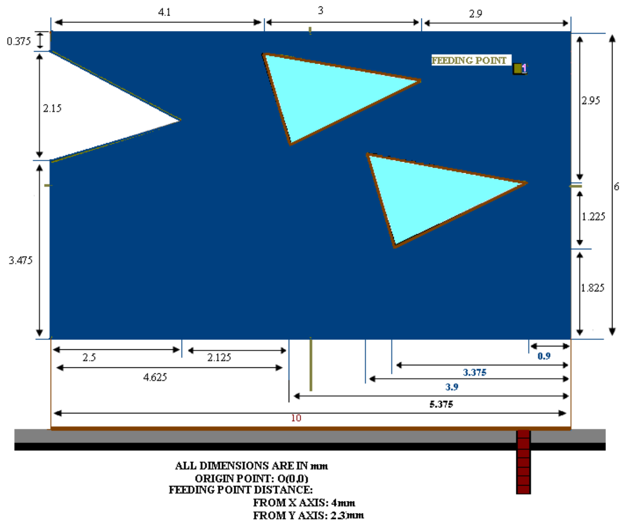

Figure 2. Simulated Antenna configuration

III. Results And Discussion

Simulated (using IE3D [10]) results of return loss in conventional and simulated antenna structures are shown in Figure 3-4. A significant improvement of frequency reduction is achieved in simulated antenna with respect to the conventional antenna structure.

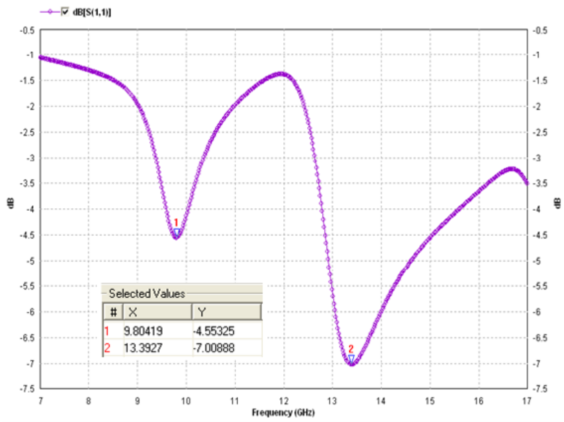

Figure 3: Return Loss vs. Frequency (Conventional Antenna)

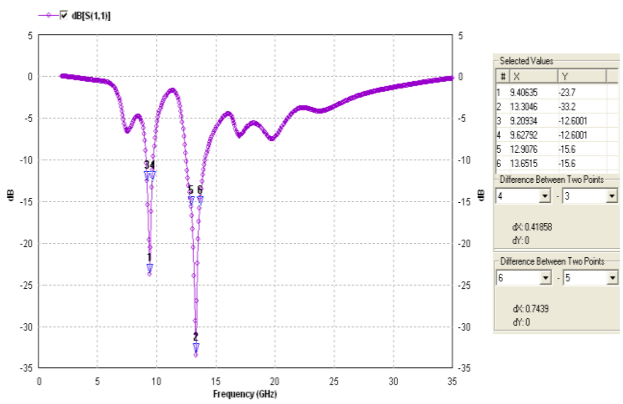

Figure 4: Return Loss vs. Frequency (Slotted Antenna)

In the conventional antenna return loss of about -7.01 dB is obtained at 13.39 GHz. Comparing fig.3 and fig.4

it may be observed that for the conventional antenna (fig.3), there is practically no resonant frequency at around 9.40635 GHz with a return loss of around -6 dB. For the simulated antenna there is a resonant frequency at around 9.40635 GHz, where the return loss is as high as -23.7dB and another frequency 13.3046 GHz with a return loss as high -33.2dB.

Due to the presence of slots in simulated antenna resonant frequency operation is obtained with large values of frequency ratio. The first and second resonant frequency is obtained at f_1 = 9.40635 GHz with return loss of about -23.7 dB and at f_2 = 13.3046 GHz with return losses -33.2 dB respectively.

Corresponding 10dB band width obtained for Antenna 2 at f1, f2 are 418.58 MHz and 748.9MHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 5-14. The simulated E plane radiation pattern of simulated antenna for 9.40635 GHz is shown in figure 5.

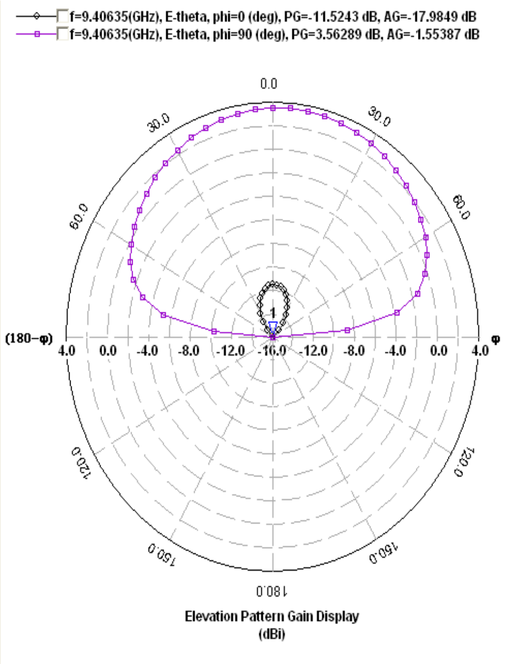

Figure 5: E-Plane Radiation Pattern for Slotted Antenna at 9.40 GHz

The simulated H plane radiation pattern of simulated antenna for 9.40635 GHz is shown in figure 6.

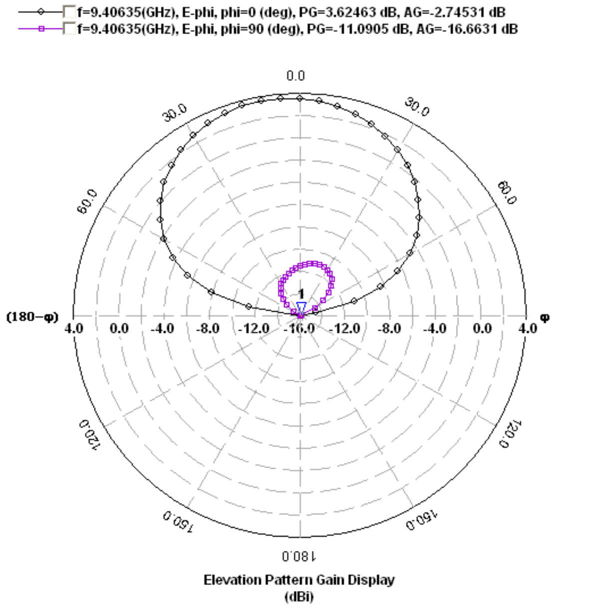

Figure 6: H-Plane Radiation Pattern for slotted Antenna at 9.40 GHz

The simulated E plane radiation pattern of slotted antenna for 13.3046 GHz is shown in figure 7.The simulated H plane radiation pattern of slotted antenna for 13.3046 GHz is shown in figure 8.

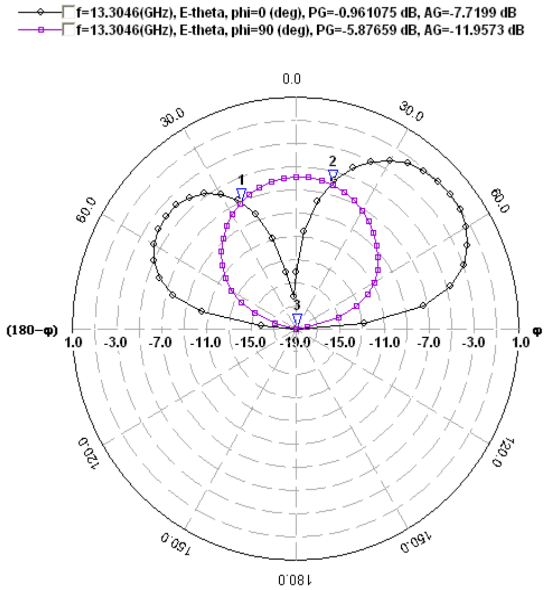

Figure7: E-Plane Radiation Pattern for slotted antenna at 13.30 GHz

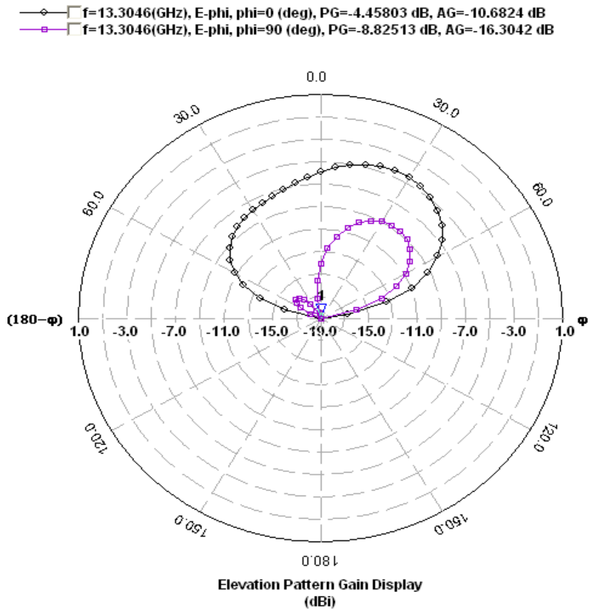

Figure 8: H-Plane Radiation Pattern for slotted antenna at 13.30 GHz

The simulated E plane & H-plane radiation pattern (3D) of simulated antenna for 13.30 GHz is shown in figure 9 & figure 10.

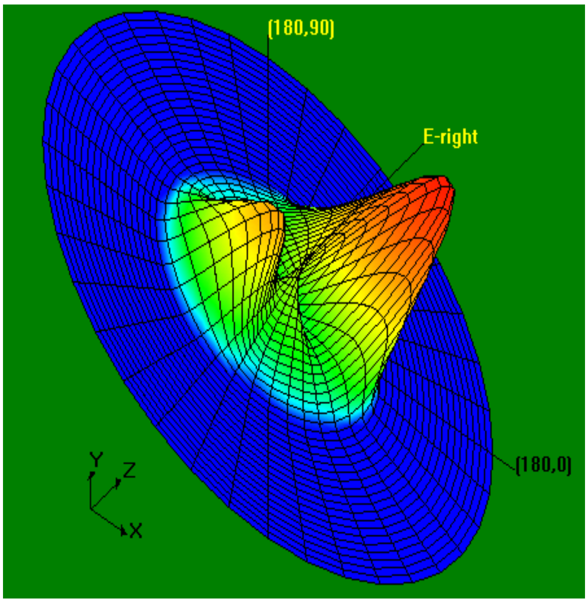

Figure 9: E-Plane Radiation Pattern (3D) for slotted antenna at 13.30 GHz

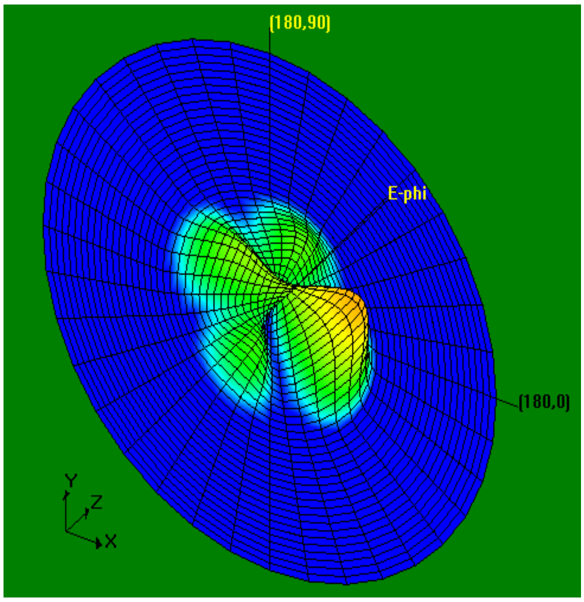

Figure 10: H-Plane Radiation Pattern (3D) for slotted antenna at 13.30 GHz

The simulated smith chart and VSWR of simulated antenna shown in figure 11 & figure 12.

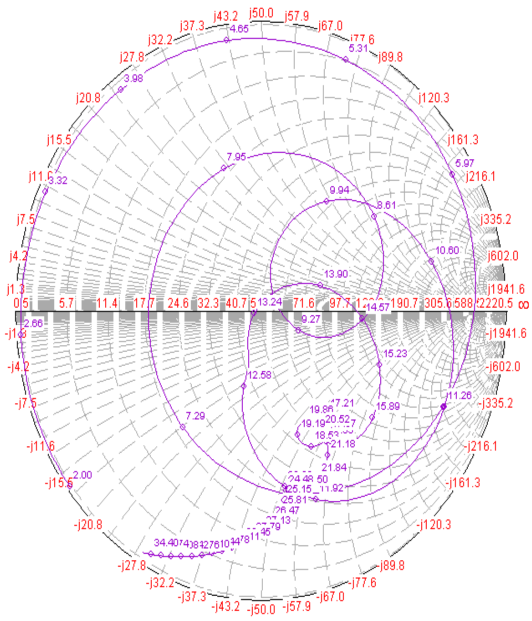

Figure11: Simulated Smith Chart for slotted antenna

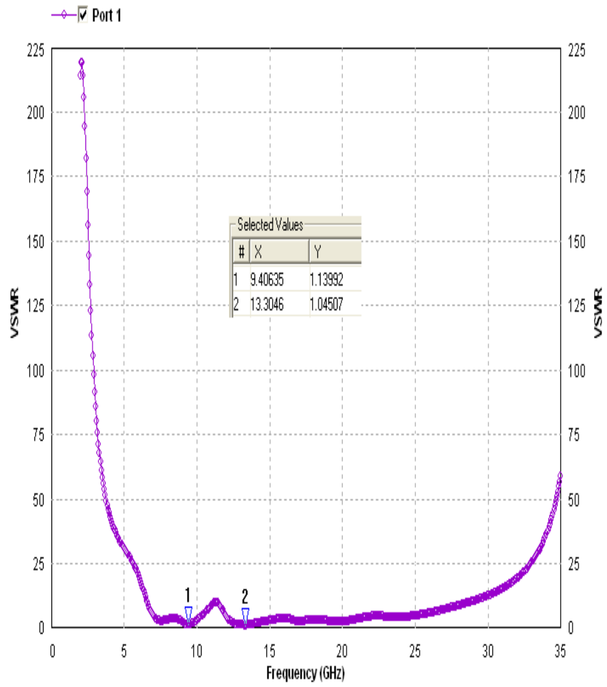

Figure 12: Simulated VSWR for slotted antenna

The simulated Cartesian E -plane & H-plane radiation pattern (2D) of simulated antenna for 13.3046 GHz is shown in figure 13 & figure 14.

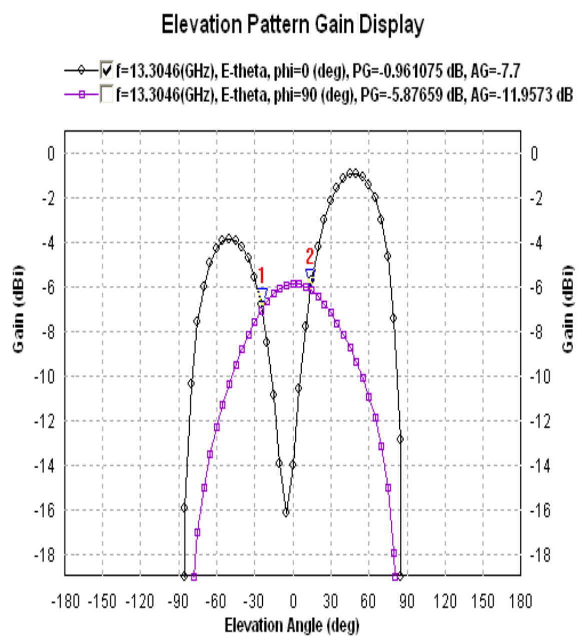

Figure13: E-Plane Radiation Pattern (2D) for slotted antenna at13.30 GHz

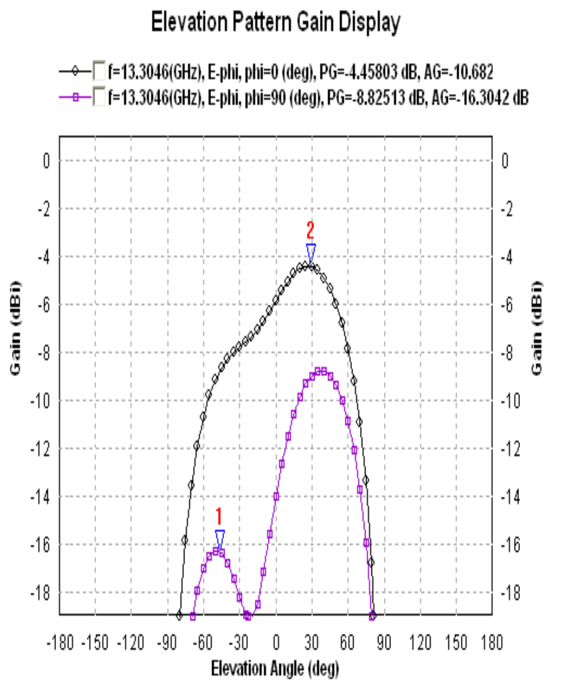

Figure 14: H-Plane Radiation Pattern (2D) for slotted antenna at 13.30GHz

All the simulated results are summarized in the following Table1 and Table2.

TABLE I. SIMULATED RESULTS FOR ANTENNA 1 AND 2 W.R.T RETURN LOSS

ANTENNA STRUCTURE	RESONANT FREQUENCY (GHz)	RETURN LOSS (dB)	10 DB BANDWIDTH (GHz)
Conventional	f_1= 9.80	-4.55	NA
	f_2= 13.39	-7.01	NA
Slotted	f_1= 9.40635	-23.7	0.41858
	f_2 = 13.3046	-33.2	0.7489

TABLE II. SIMULATED RESULTS FOR ANTENNA 1 AND 2 W.R.T RADIATION PATTERN

ANTENNA STRUCTURE	RESONANT FREQUENCY (GHz)	3DB BEAMWIDTH (^{0})	ABSOLUTE GAIN *(dBi)*
Conventional	f_1= 9.80	NA	NA
	f_2= 13.39	NA	NA
Slotted	f_1= 9.40635	136.189	3.73214
	f_2 =13.3046	131.27	0.330357
Frequency Ratio for Conventional Antenna			f_2 / f_1 = 1.366
Frequency Ratio for Slotted Antenna			f_2 / f_1 = 1.414

IV. CONCLUSION

This paper focused on the simulated design on differentially-driven microstrip antennas. The main drawback of printed antenna was impedance bandwidth. Simulation studies of an unequal arrow based printed antenna have been carried out using Method of Moment based software IE3D [18]. Introducing slots at the edge of the patch size reduction of about 53.26% has been achieved. The 3dB beam-width of the radiation patterns are 136.189^0 (for f_1), 131.27^0(for f_2) which is sufficiently broad beam for the applications for which it is intended.

The resonant frequency of slotted antenna, presented in the paper, designed for a particular location of feed point (4 mm, 2.3 mm) considering the centre as the origin. Alteration of the location of the feed point results in narrower 10dB bandwidth and less sharp resonances.

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